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LATE-HOLOCENE VEGETATION CHANGES FROM THE LAS FLORES CREEK COASTAL LOWLANDS, SAN DIEGO COUNTY, CALIFORNIA

R. SCOTT ANDERSON
Center for Environmental Sciences & Education, and Quaternary Studies Program, Box 5694, Northern Arizona University, Flagstaff, AZ 86011

BRIAN F. BYRD
ASM Affiliates, Inc., 543 Encinitas Blvd., Suite 114, Encinitas, CA 92024 and Department of Anthropology, University of California, San Diego, CA 92093

ABSTRACT

The vegetation history of coastal southern California is incompletely known, due primarily to a lack of suitable sites for preservation of subfossil organic remains, and destruction of sites by recent human impact. One coastal site, along Las Flores Creek in San Diego County, has yielded a pollen record, enabling us to reconstruct vegetation and climatic changes for the last ca. 4300 radiocarbon years. Pollen from riparian plants, including *Typha* (cattail) and Cyperaceae (sedges), are common between ca. 4000 and 2600 years ago. *Cupressus,* or a closely related tree, may have grown along this riparian corridor, suggesting formerly larger range for this plant. By ca. 2600 years ago, a vegetation mosaic including elements of the coastal sage, chaparral, and grassland communities, were established near the site, persisting until the introduction of exotic weed and tree species within the last century.

The pollen record from Las Flores Creek provides information on the environment of the Native American population during the Late Holocene. Local plant species undoubtedly provided resources for seasonal occupation of the coast, which supplemented extensive shellfish collecting, especially after ca. 2000 years ago. An increase in pollen from the Chenopodiaceae at that time may correspond to local human-caused disturbances.

Analysis of pollen assemblages from stratigraphic profiles in southern California has lagged significantly behind studies in other parts of the state (Adam 1985). The primary reasons for this include a perceived lack of suitable sites, as well as generally poor pollen preservation from sites that have been analysed. Because traditional sites for pollen profiles (i.e., lakes or bogs) in this arid region are generally missing at low elevations in southern California, alternative sites, such as alluvial sections or estuaries, must be investigated in order to provide information on local vegetation changes for the coastal region.

Pollen recovery from alluvial and colluvial sections at locations in California and the American Southwest has been highly to moderately successful. For example, Anderson and Smith (1994) and Koehler and Anderson (1994) reported on montane alluvial/colluvial profiles at middle elevations in the Sierra Nevada. Pollen preservation was excellent in these sections, which occurred as low as 1509 m.

Holocene pollen profiles have been investigated as well from several coastal estuary sites in southern California, including Los Penasquitos Lagoon and Mission Bay in San Diego (Mudie and Byrne 1980), San Joaquin Marsh in Orange County (Davis 1992), and Abalone Rocks Marsh on Santa Rosa Island (Cole and Liu 1994). Pollen deposited in estuarine sediments contains assemblages from terrestrial, freshwater, and marginal marine plants, and has been used to infer changes in sealevel as well as the terrestrial record from the adjoining uplands. A late Pleistocene pollen record was also obtained from a rockshelter on San Miguel Island (West and Erlandson 1994).

In January 1994, we discovered a thick alluvial section near the mouth of Las Flores Creek, on Camp Pendleton Marine Base, San Diego County. Our investigations were part of ongoing archaeological excavations on the Base (Byrd 1996). Pollen preserved in this 4.75 m section has allowed us to reconstruct the vegetation history of the upland and riparian habitats near the shoreface, in contrast to those from the sub- and near-tidal marshes of southern San Diego, Orange, and Ventura Counties named above. The data from the Las Flores Arroyo not only provide a Late Holocene record from a region with inadequate paleoenvironmental coverage, but also provide an environmental context useful in archaeological reconstructions of the region.

Location and Characteristics of Site

The Las Flores Arroyo site is located along Las Flores Creek, at the mouth of Las Pulgas Canyon, on Camp Pendleton Marine Base (Las Pulgas Canyon USGS 7.5′ Quad; 33°17′30″N latitude; 117°27′30″W longitude; Fig. 1). The top of the section occurs at an elevation of ca. 6 m. The deposit is a deeply incised Holocene alluvial terrace, with stacked silts and sands comprising both alluvial deposits and paleosols (Fig. 2A, personal observations, and Waters 1996).

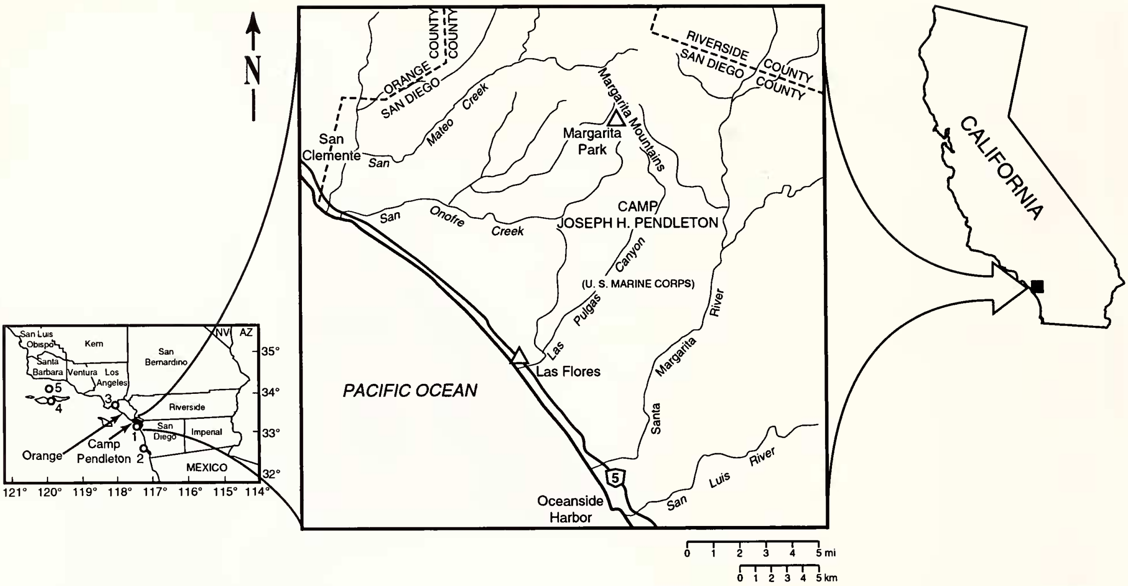

FIG. 1. Location of the Las Flores pollen site, San Diego County, California, as well as other nearby sites mentioned in the text. 1 = Las Flores profile (this paper); 2 = Los Penasquitos Lagoon and Mission Bay (Mudie and Byrne 1980); 3 = San Joaquin Marsh (Davis 1992); 4 = Abalone Rocks Marsh (Cole and Liu 1994); 5 = Santa Barbara Basin (Huesser 1978; Byrne et al. 1977).

The vegetation of Camp Pendleton and the adjacent coastal uplands was mapped by Pacific Southwest Biological Services, Inc. (1986); Zedler et al. (unpublished) has studied the community composition of the Base. At least four distinct plant communities occur within 500 m of the Las Flores site (Fig. 2B). Community composition and vegetation distribution on the Base is heavily influenced by past land use activities, including farming and grazing, fire, construction activities, and military training (Zedler et al. unpublished).

The arroyo itself presently supports Cottonwood/Willow Riparian Woodland. Common tree species in the riparian zone include *Populus fremontii* S. Watson ssp. *fremontii, P. balsamifera* L. ssp. *trichocarpa* (Torrey & A. Gray) Brayshaw, *Salix gooddingii* C. Ball, *S. lasiolepis* Benth. and *S. laevigata* Bebb. Typical associates include *Platanus racemosa* Nutt. (California sycamore), as well as *Artemisia douglasianna* Besser (mugwort), *Baccharis salicifolia* (Ruiz Lopez & Pavon) Pers. (mule-fat), *Conium maculatum* L. (poison hemlock), *Xanthium strumarium* L. (cockle burr), *Urtica dioica* L. (stinging nettle) and *Vitis girdiana* Munson (wild grape) (Zedler et al. unpublished; Beauchamp 1986). The alluvial deposit itself is covered by Southern Willow Scrub. This vegetation unit includes the willows mentioned above, plus *Salix exigua* Nutt. Associated herbaceous species include *Toxicodendron diversilobum* (Torrey & A. Gray) E. Greene (poison oak), *Ambrosia psilostachya* DC. (ragweed), *U. dioica, X. strumarium, Artemisia douglasianna,* and the non-natives of *C. maculatum,* and *Foeniculum vulgare* Miller (sweet fennel).

On the headland immediately south of the arroyo is found a small patch of Diegan Coastal Sage Scrub, dominated by low (<2 m), soft-leaved, drought-deciduous shrubs (Zedler et al. unpublished). Plant composition is variable across gradients of exposure, elevation and soil type. However, dominant species include *Artemisia californica* Less. (California sagebrush), *Salvia mellifera* E. Greene (black sage), *Malosma laurina* (Nutt.) Abrams (laurel sumac), *Baccharis pilularis* DC (coyote brush), *Lotus scoparius* (Nutt.) Ottley (deerweed) and *Eriogonum fasciculatum* Benth. (California buckwheat). Chaparral species potentially occurring within this community include *Ceanothus crassifolius* Torrey (hoaryleaf ceanothus), *Rhamnus ilicifolia* Kellogg (holly-leaf redberry), *Rhus integrifolia* (Nutt.) Brewer & S. Watson (lemonadeberry), *Heteromeles arbutifolia* (Lindley) Roemer (toyon), and *Cercocarpus betuloides* Torrey & A. Gray (mountain-mahogany).

Non-Native Annual Grassland presently occupies a large area south of Las Flores. Common introduced grasses include *Bromus diandrus* Roth, *B. madritensis* L. ssp. *rubens* (L.) Husnot, *B. hordeaceus* (ripgut, foxtail chess and soft chess), *Avena barbata* Link, *A. fatua* L. (slender and wild oat), *Hordeum* spp. (wild barley), and *Lolium multiflorum* Lam. (Italian ryegrass).

METHODS

The Las Flores Arroyo wall face was sampled on 5 May 1994. Using an extension ladder to reach the

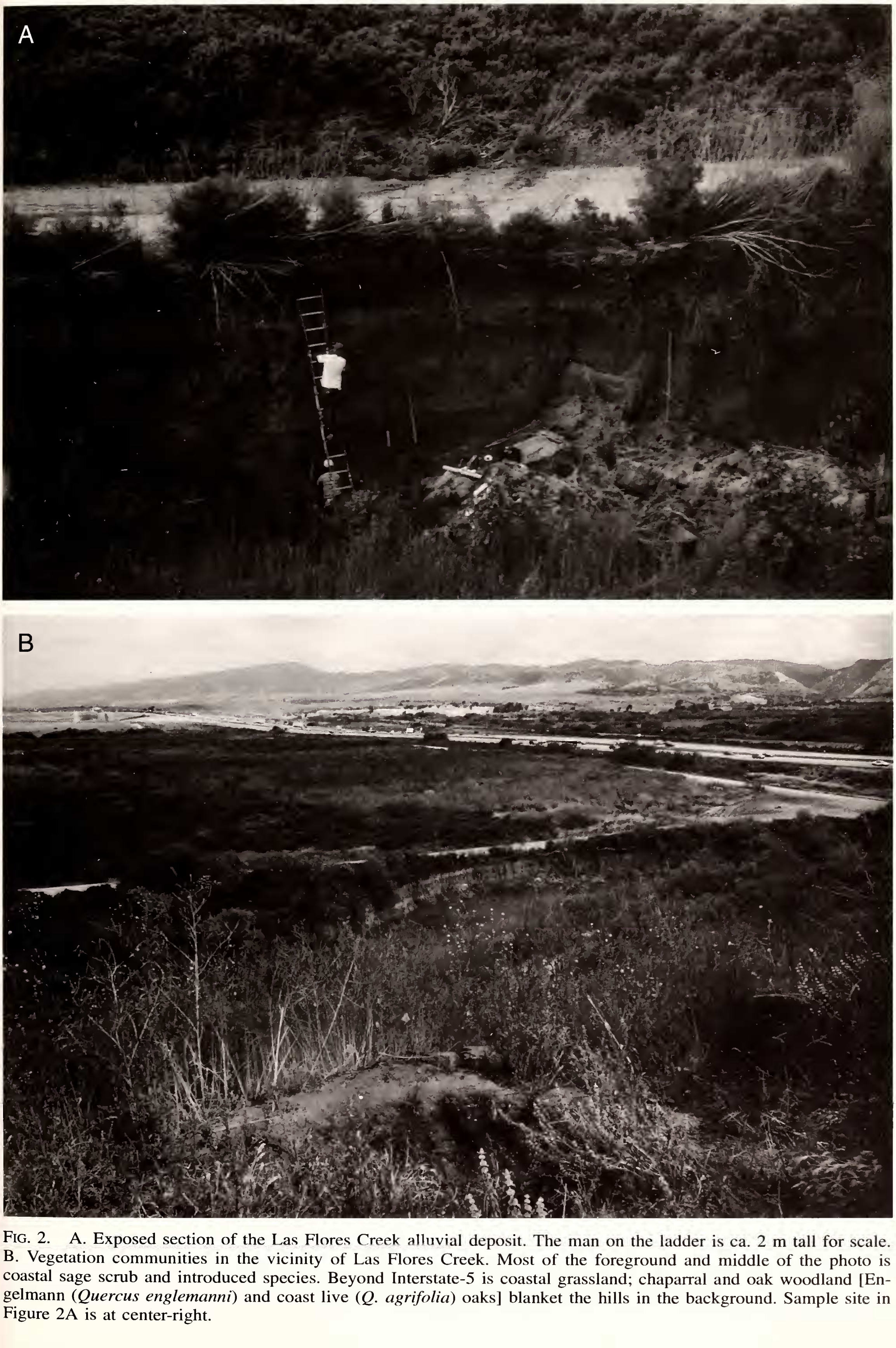

FIG. 2. A. Exposed section of the Las Flores Creek alluvial deposit. The man on the ladder is ca. 2 m tall for scale. B. Vegetation communities in the vicinity of Las Flores Creek. Most of the foreground and middle of the photo is coastal sage scrub and introduced species. Beyond Interstate-5 is coastal grassland; chaparral and oak woodland [Engelmann (*Quercus englemanni*) and coast live (*Q. agrifolia*) oaks] blanket the hills in the background. Sample site in Figure 2A is at center-right.

profile top, the arroyo face was scraped clean with a trowel, and samples of the sediment were collected with a hammer and chisel from the face. Samples were taken at ca. 25 cm intervals from the surface of the deposit to 475 cm depth (total of 20 pollen samples). Samples were placed in 1-gallon bags for transport back to the laboratory.

At Northern Arizona University's Laboratory of Paleoecology (LOP), the pollen samples were processed by a technique which included suspension of a 20 cc subsample of sediment in dilute HCl to dissolve carbonates. *Lycopodium* tracer tablets are added at this step to allow for the calculation of pollen concentration. Subsequent steps included overnite suspension in HF to dissolve silicates, and flotation of the pollen in $ZnBr_2$. The resulting pollen residue was washed with distilled water and placed in glycerol for examination on microscope slides. Each sample contained abundant charcoal, so a final step was added in which we suspended the pollen residue in sodium pyrophosphate and filtered it through an 8 μ mesh. This eliminated most of the charcoal, making the sample more easily counted. The resulting pollen samples were counted to a fixed pollen sum as necessary on a Leitz microscope, with reference to the modern pollen reference collection at the LOP. The pollen sum included all terrestrial pollen types (plus degraded and unknowns), and excluded aquatics (Cyperaceae, *Typha*), riparian trees (*Tamarix*, cf. *Platanus, Populus, Juglans, Alnus* and *Salix*), and spores.

Three samples were taken for radiocarbon dating, at 100, 170 and 370 cm depth. Radiocarbon dates were performed by Beta Analytic, Miami.

Conventions for pollen identifications. Forty-one pollen and four spore types were recognized, exclusive of deteriorated and unknown grains. Where possible, grains were assigned to the generic level, more rarely to the family level. Several groupings were further subdivided, including the Asteraceae, the genus *Pinus*, the Malvaceae, and the spores. The following conventions were used for those groups that were subdivided:

Asteraceae. Pollen of the Asteraceae were separated into 11 groups. Main groupings included *Ambrosia* (ragweed), *Artemisia* (sage), *Cirsium* (thistle), Liguliflorae (chicory), and other Asteraceae. However, since a majority of grains were in the other Asteraceae group, six morphotypes were recognized, based upon the size and shape of the spines, as well as the size of the grain itself. Based upon an unpublished list of plants growing on Camp Pendleton Marine Base, the following genera were included in the 11 Asteraceae subgroups. *Ambrosia*-type included *Ambrosia, Iva,* and *Xanthium. Artemisia*-type included only *Artemisia. Cirsium*-type included *Cirsium* and *Centaurea.* Liguliflorae included *Cichorium, Lactuca,* and *Taraxacum.* Each of these species has been introduced to the Base, thus ancient pollen grains must include additional species not presently near the site. *Baccharis*-type included *Baccharis, Brickellia, Conyza, Cotula, Encelia, Erigeron, Eriophyllum, Gutierrezia, Helianthus, Heterotheca, Pluchea,* and *Senecio. Coreopsis*-type included only *Coreopsis. Chaenactis*-type included *Bebbia, Chaenactis,* and *Viguiera. Solidago*-type included *Euthamia, Solidago,* and *Gnaphalium.* Two additional members of the Asteraceae include Type 4 and Type 6, not referable to other members of the family presently identified.

Pinus. Pine pollen was separated into diploxylon-type (*Pinus coulteri* D. Don and *P. ponderosa* Laws.; both presently occur on the Base), and undifferentiated pine-type.

Brassicaceae. Only one pollen type of mustard was recovered primarily in the most recent sediments. This was assigned to the genus *Brassica,* because of the ubiquity of the plant.

Apiaceae. Only one pollen type of umbel was recovered, primarily contemporaneous with *Brassica.* The pollen type is most similar to *Foeniculum,* which is also the most common umbel at the site today.

Malvaceae. Specimens of *Sphaeralcea* and an unknown Malvaceae occurred in the pollen assemblages.

Spores. Four types of trilete spores occurred in the assemblages. These were assigned to *Cheilanthes*-type, *Ophioglossum*-type and two unknowns.

RESULTS

Sediments. Sediments of the pollen profile were described in detail by Waters (1996). The column consists of six major units. Unit I (bottom-most unit) is a brown sandy clay with a paleosol at the top, containing calcium carbonate nodules and root casts. Unit II is a silty sand, also containing calcium carbonate nodules and root casts, capped by another paleosol. Unit III is a fining upward sequence with sand at the base, fining upward to sandy silty clay at the top. A third paleosol caps the sequence. Calcium carbonate was also present in these sediments. Unit IV, a silt and silty clay, again contained pedogenic features, including calcium carbonate. Unit V was a gray, bioturbated silt, with archaeological debris and marine shells throughout the deposit. The upper unit, VI, is highly disturbed, and may consist of spoil sediments.

Chronology. Three radiocarbon dates were obtained from this profile (Table 1). Beta-75375 (1800 ± 80 yr BP) came from Unit IVb, Beta-76432 (2610 ± 80; collected and submitted by Mike Waters) came from Unit IIIb, and Beta-75376 (4230 ± 60 yr BP) came from near the top of Unit Ib. The first and third samples contained low carbon content, and required extended counting. The low standard error suggests that little if any contamination by older or

TABLE 1. RADIOCARBON DATES FROM THE LAS FLORES POLLEN PROFILE.

Lab #	Depth (cm)	Conventional C14 age	Calibrated calendar yrs
Beta-75375	100	1,800 ± 80	AD 60–420
Beta-76432	170	2,610 ± 80	BC 905–515
Beta-75376	370	4,230 ± 60	BC 2920–2610

younger carbon was present, even though each sample consisted of bulk sediments.

Pollen. Forty-one pollen types were identified from the Las Flores pollen assemblages (Appendix Table 1). Pollen preservation varied from very good in levels near the surface, to very poor near the bottom. This was reflected both in the number of grains counted to achieve a rational pollen sum, as well as the pollen concentration from each of the samples. Pollen sums exceeded 300 grains in samples above 150 cm depth, were ca. 200 grains between 175 and 225 cm depth, dropped to below 100 grains from 250 to 300 cm, and were essentially barren below 330 cm depth (Appendix Table 1). Similarly, pollen concentrations (grains/cc) averaged 25,400 grains/cc (range = 888 to 83,700) in the top 150 cm, but dropped to 1815 grains/cc (range 521 to 6060) from 175–225 cm. Pollen concentrations below 225 cm were generally a couple of hundred grains/cc or less (Appendix Table 1).

Pollen zones. Based upon composition of the pollen assemblages, as well as pollen concentration values, five pollen zones are recognized. Pollen zones correspond largely to major breaks in sedimentary composition, as determined by Waters (1996). The pollen assemblages are described below:

Pollen Zone I (bottom of profile [475 cm] to 315 cm). Pollen is essentially absent from this section of the core (Fig. 3; Appendix Table 1). Individual grains of *Cupressus*-type, *Baccharis*-type, Brassicaceae, and Apiaceae were found, but their numbers were insufficient to warrant an interpretation. These sediments correspond largely to Waters' (1996) Units I and II. The single radiocarbon date from this unit is middle Holocene (4230 ± 60 yr BP).

Pollen Zone II (ca. 315–140 cm). Pollen concentrations increase substantially throughout the zone, from negligible amounts at the bottom to several thousand near the top. This trend is paralleled by an increase in degraded grains (see below). The dominant pollen type in the lower portions of the zone is *Cupressus*-type, but above ca. 225–250 cm *Cupressus* declines as several pollen types of the Asteraceae increase (Fig. 3). Prominent among these is the *Baccharis*-type, though *Solidago*-, *Coreopsis*-, and *Chaenactis* types also become important. Members of the *Ambrosia* group, as well as the Liguliflorae, are abundant. *Artemisia* and grasses also increase toward the end of the zone. Spores of several species are prominent during this zone, including *Cheilanthes, Ophioglossum,* and two unidentified types. Aquatic herbs are most abundant during the early portion of the zone. Pollen Zone II largely corresponds to Waters' (1996) Unit III. Waters collected a radiocarbon date near the top, dating 2610 ± 80 yr BP.

Pollen Zone III (ca. 140–100 cm). Pollen in this zone is little changed from Zone II below it, except in the relative absence of *Cupressus*-type and the increase for the first time in pollen of Chenopodiaceae-*Amaranthus* plants (Cheno-Am) (Fig. 3). The pollen assemblage is still dominated by members of the Asteraceae, though *Coreopsis*- and *Chaenactis*-types are less important. Other than a few grains of sedge (Cyperaceae) no aquatic or riparian pollen is found. This zone corresponds to Waters' (1996) Unit IV. The single radiocarbon date near the top of this unit is 1800 ± 80 yr BP.

Pollen Zone IV (ca. 100–40 cm). Major changes in the pollen profile begin in this zone. Pollen concentrations are the highest of any pollen zone, averaging 67,750 grns/cc. The pollen assemblage continues to be dominated by *Baccharis*- and *Solidago*-types, but Cheno-Am, *Artemisia,* and grasses remain prominent. *Cupressus* and *Ambrosia* are absent. One pollen type, *Eriogonum,* becomes most abundant in this zone, while a second, *Brassica*-type, is first recognized here. Riparian indicators (*Alnus, Salix,* and Cyperaceae) are also important once again. Pollen zone IV corresponds to Unit V of Waters (1996).

Pollen Zone V (ca. 40 cm to the profile top). This pollen assemblage is the most distinctive of any in the profile. The assemblage is dominated by *Brassica*- and *Foeniculum*-type pollen, both indicative of severe disturbance. Cheno-Am pollen, another disturbance indicator, reaches its maximum here. Tree pollen includes *Pinus,* and the introduced species *Eucalyptus, Olea,* and *Tamarix.* Riparian species include cf. *Platanus, Juglans, Salix, Alnus,* and Cyperaceae (Fig. 3). This zone corresponds to Waters' (1996) Unit VI.

DISCUSSION

We examined several sites along the Camp Pendleton coastline for potential reconstruction of Holocene paleoenvironments. Our reconnaissance, as well as those of Waters (1996), suggested that analysis of alluvial deposits provides the best opportunity for paleoecological reconstruction there. Waters (1996) and Waters et al. (in press) identified two types of stream systems operating along the coast. Some streams, like Santa Margarita Creek, have large drainage basins with through-flowing discharge capable of maintaining an open channel to the ocean. Other fluvial systems have considerably smaller drainage basins with smaller discharg-

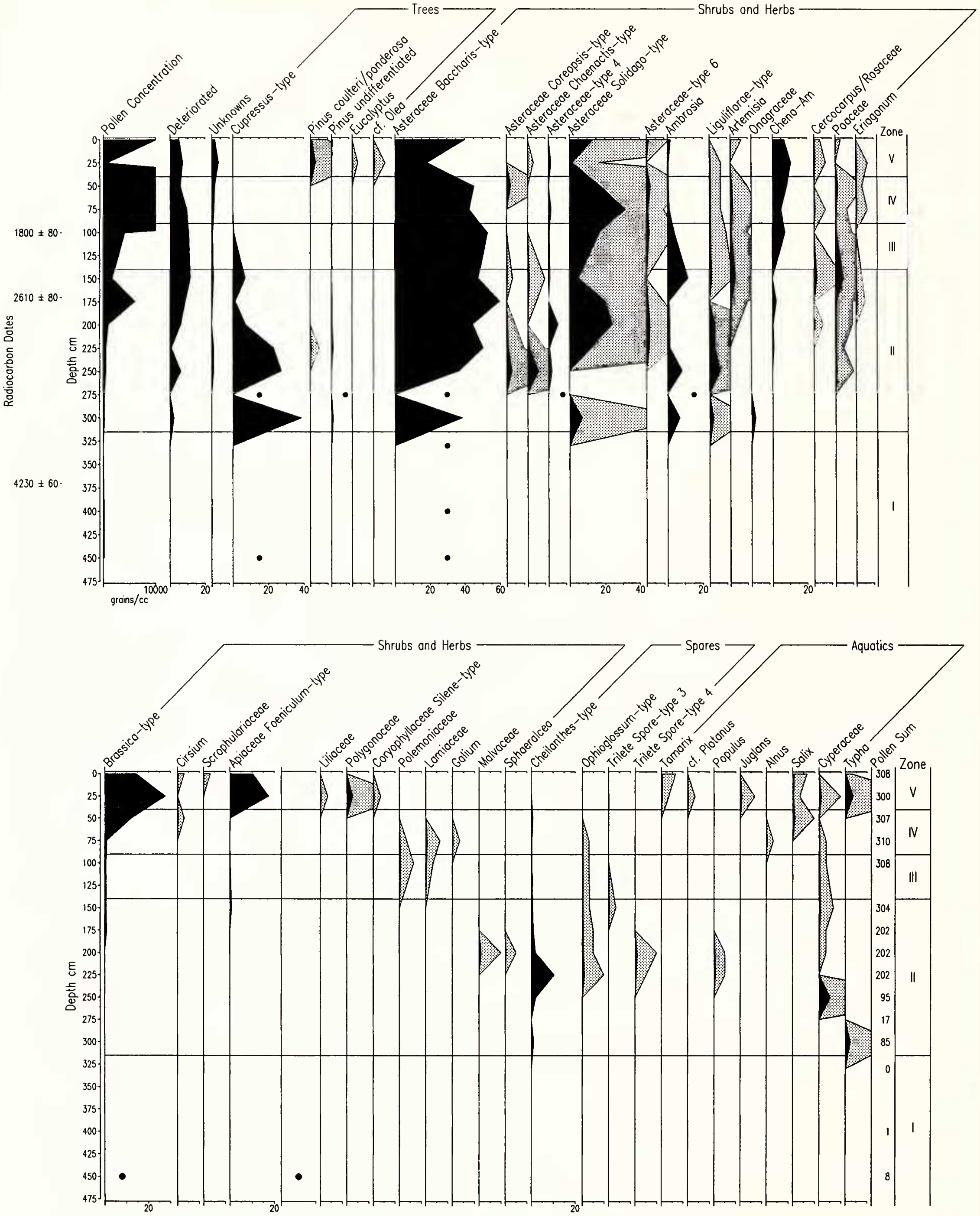

FIG. 3. Pollen percentage diagram for the Las Flores Creek pollen profile. Silhouettes are the pollen percentages ×10. Dots represent single-grain occurrences of the individual pollen types.

es, and do not terminate at the ocean. Instead, these drainages most often terminate in lagoons or sloughs, dammed by beach sand. During large storms when stream discharge increases, a channel cuts through the beach deposit, and the slough drains. Subsequently, shoreline processes restore the beach and the slough forms once again. The Las Flores Creek deposit falls in the latter category.

Differences of opinion exist between researchers regarding the interpretation of alluvial pollen assemblages. Hall (1985) reviewed the literature from alluvial sites in the Southwest. Though local vegetation changes can be interpreted from the data, Hall noted that many profiles contain unconformities, with pollen sequences typically beginning or ending during the late Pleistocene or middle Holocene, due to changes in sedimentation, erosion, or soil formation. Fall's (1987) work in Arizona suggested to her that alluvial pollen was unreliable for reconstruction of regional paleoenvironments. For most contexts, it should be assumed that alluvial pollen integrates vegetation occurring near the stream or channel. At a minimum, alluvial pollen records local vegetation changes, often associated with paleohydrologic changes, and tied to climate.

The record exposed along Las Flores Creek represents at least the last ca. 4300 years, perhaps longer. It is an important record since records from only three other coastal sites (Davis 1992; Cole and Liu 1994; Mudie and Byrne 1980) have together defined the Late Holocene sequence for southern California. Each of these studies record vegetation changes within coastal salt marshes, while the record from Las Flores Creek is largely from a coastal bluff. In addition, the Las Flores site exists alongside a prehistoric archaeological site occupied by Native Americans (during Pollen Zone IV).

The pollen changes presented here record some startling vegetation changes along the Las Flores corridor, though unfortunately, the record cannot be interpreted with any precision below ca. 315 cm depth. Pollen Zone I (sedimentary Units I and II), deposited primarily before ca. 4200 yr BP, record a basal and succeeding unit of deposition, each capped by soil development. Pollen preservation was largely unfavorable in these sediments. Poor preservation and low concentrations could result from intense decomposition during soil formation, or rapid sedimentation and dilution of pollen. Existing evidence cannot exclude either hypothesis.

However, during Pollen Zone II time (depositional Unit III), pollen preservation increased from bottom to top. Waters (1996) described this unit as a fining upward sequence, implying channel infilling and overbank deposition. The resulting pollen assemblage provides some support for this interpretation, as well as insight into the vegetation communities that existed along the banks of the ancient Las Flores Creek. Riparian indicators (*Typha*, Cyperaceae, *Ophioglossum*-type) are most prominent in the coarser sediments deposited near the opening of Zone II, and become less important with time. The increase in degraded grains near the top of the unit are indicative of intense soil formation. A third period of soil formation commenced sometime around 2600 years ago.

The occurrence of *Cupressus*-type pollen is of great interest, yet becomes problematic, for several reasons. *Cupressus* does not occur on Camp Pendleton today. The abundance of *Cupressus*-type pollen during this time is suggestive of a riparian gallery forest of *Cupressus*, or, alternatively, transport of the pollen from nearby upstream locations. The disappearance of *Cupressus*-type pollen during the waning stages of Zone II time could then represent movement of the stream away from the present profile site, or local extermination of the species, perhaps due to more frequent drying of the slough. Problematic is the fact that today *Cupressus guadalupensis* ssp. *forbesii* and *C. arizonica* ssp. E. Greene *stephensonii* are both found in chaparral foothills, though the former presently occurs as low as 150 m (Beauchamp 1986). A remnant population of the former grows in the Santa Ana mountains of Orange County (Vogl et al. 1988). The morphology of the grain is not referable to *Juniperus*, and is less like *Calocedrus*, both of which occur at higher elevations and away from the site today. All members of the Cupressaceae produce copious amounts of pollen, and the absence of *Cupressus*-type pollen higher in the profile suggests local extirpation of the plant.

Increases in pollen of *Artemisia*, *Eriogonum* and Poaceae, as well as the establishment of a large number of species in the Asteraceae family, suggest establishment of a vegetation mosaic, including coastal sage, chaparral and grassland communities, near the site by ca. 2600 years ago. This mosaic has largely persisted until the present, with allowances for recent introductions of non-native plants and changes associated with human disturbance. Pollen spectra from Santa Barbara Basin cores show similar increases in species of coastal sage scrub (*Artemisia*, *Eriogonum*, Labiatae) and chaparral (Rosaceae-Rhamnaceae-Anacardiaceae) during the Late Holocene (Heusser 1978). Since the source of pollen extracted from this marine core is the area drained by the Ventura and Santa Clara Rivers, we conclude that the record from Las Flores is a local example of a large-scale development of coastal vegetation in southern California. The Las Flores record is important in confirming this theory, and fixing the timing of the vegetation change.

The pollen assemblage of Zone III time largely represents continuation of conditions during Zone II, and a transition into Zone IV times. Sediments deposited during Zone IV time (Unit V of Waters, 1996) include a prehistoric archaeological occupation represented in the section by marine shells (dominated by *Donax gouldii*), fire-affected rock, and charcoal; a radiocarbon date suggests deposition centered around 1800 years ago. Archaeological excavations of this site directly to the north revealed an extensive coastal shell midden also radiocarbon dated between 1800 and 1500 years ago (Byrd 1996). This prehistoric occupation is part of a regional trend toward intensive exploitation of periodic *Donax* resurgences during the last 2000 years (Byrd, in press; Reddy 1996a; Laylander and Saunders 1993). These sediments are darker colored and considerably more organic than those below. This may have contributed to the higher concentration of pollen found during Zone IV time. Though the pollen is not significantly different from below, indicators of local disturbance (e.g., *Brassica*-type and Cheno-Am pollen) suggest human activity. (*Brassica*-type pollen probably includes several species or genera, and probably does not represent the same species found in Zone V above). The first occurrence of willow pollen suggests that the modern willow scrub community originated on the deposit surface during this time.

No pollen types indicative of aboriginal cultivation were found in these sediments. Recent investigations have demonstrated that aboriginal occupation patterns were probably not characterized by agriculture or horticulture (see Shipek 1989), but instead entailed intensive exploitation of wild plant and animal resources, of which shellfish, fish, small terrestrial mammals, grasses, and nuts were dietary staples (Byrd 1996; Glassow and Wilcoxon 1988; Jones 1991, 1992). The slowing of sea-level rise during the late Holocene converted the region's mainly rocky shorelines into larger stretches of sandy beach (Inman 1983), and caused a decline in shellfish productivity (Warren 1964). However, periodic exploitation of massive resurgences of sandy beach swelling *Donax* and offshore fishing during the last 2000 years provided a niche in which this area's coastline could be occupied for an extended period each year. Based on seasonality analysis of fish otoliths and paleoethnobotanical remains, this site along Las Flores Creek was occupied at least from March through October (Hudson 1996; Reddy 1996b). If abandoned during the winter, inland sites situated among oak groves would have provided an alternative seasonal niche to exploit.

The uppermost sediments and pollen are certainly recent in age, dating to the occupation of Europeans. Several pollen types confirm this interpretation. Dominating the pollen assemblage are *Foeniculum*-type (Apiaceae) and *Brassica*-type (Brassicaceae). *Foeniculum vulgare* and *Brassica nigra,* which today grow on the deposit surface, are both native to Europe (Beauchamp 1986). *Eucalyptus* trees, native to Australia, were imported to North America and planted in the San Francisco region prior to 1860 (Ingham 1908); they were first planted in San Diego County during the period 1902–1910 (Stanford 1970; Mudie and Byrne 1980). *Tamarix,* a native of the Middle East and Old World, was widely planted in the southwestern U.S., and has escaped along watercourses. Most of the plants in cultivation here were part of a clone established by J. J. Thornber in Arizona, during the early part of the 20th century (Benson and Darrow 1981; see also Baum 1967). Arroyo cutting probably intensified during Zone V time as witnessed by the increase in riparian pollen types (Fig. 3). This may have allowed the deposit surface to dry somewhat, causing weedy annuals to be favored.

Though timing of the Pollen Zone I/II transition is uncertain, interpolation between radiocarbon dates suggests that the major palynological change occurred ca. 3800 years ago, consistent with an increase in effective precipitation, following a drier middle Holocene. Abundant evidence from the Sierra Nevada and other locations suggest that effective precipitation increased during the late Holocene. Anderson and Smith (1994) reported wet meadow deposition originated in the Sierra by ca. 4500 years ago, indicating rising groundwater levels. Treeline was higher (warmer conditions) in the Sierra and adjacent White Mountains prior to ca. 3700 years ago (LaMarche 1973; Scuderi 1987). Along the coast, Cole and Liu (1994) inferred increased precipitation on Santa Rosa Island beginning ca. 3250 yr BP, while Davis (1992) inferred drier conditions. Cole and Liu (1994) suggested that the disparity might be due to the proximity of the Santa Rosa site to the ocean, which, like the Las Flores site, is less than 100 m from the shorefront, while San Joaquin Marsh (Davis 1992) is ca. 7 km inland.

Thompson et al. (1993) presented maps of the effective moisture for the western United States, depicting the maximum effective moisture for the entire Pacific Coast during the last ca. 3000 years. Unfortunately the only blank spot on the map lies in southern California. The data presented here suggest that southern coastal California has responded to climatic change in a manner similar to the rest of coastal California and the Pacific Northwest.

Conclusions

Analysis of pollen from a stratigraphic section along Las Flores Arroyo has allowed us to reconstruct the local paleoenvironment over the last several thousand years. The Las Flores data are important because they represent one of only a handful of Holocene paleobotanical sites along the southern California coast, and are the first attempt to reconstruct paleoenvironments from Camp Pendleton Marine Base.

In most cases, pollen changes can be correlated with sedimentary changes, as determined by Waters (1996). Declines in pollen concentration with depth are indicative of the increased length of time that the pollen has been subject to decomposition. Alkaline conditions, as shown by petrocalcic nodules, are unfavorable for pollen preservation; in general, the greater oxidation potential of sandy sediments also contributes to increased pollen decomposition.

Even so, the pollen evidence tells us that the paleoenvironment during Zone II time (near the end of the Middle Holocene) was considerably different from the modern environment. *Cupressus* (or a similar tree) probably grew along the watercourse. This suggests wetter conditions than occur today during the early part of Zone II, allowing the tree to grow at lower elevations. Subsequent stabilization of the surface and colonization by herbs occurred by about 2600 years ago. These conditions were maintained until the present.

During the archaeological occupation of the valley floor, Pollen Zone IV, the vegetation growing locally was little changed from earlier, but increased disturbance may be seen by elevated Cheno-Am pollen. No distinctly identified cultivars were noted, but pollen evidence suggests semi-permanent water nearby probably provided at least a seasonal freshwater supply.

The historic period is recorded in the top 30–40 cm of the profile by the occurrence of several pollen types of introduced species. We do not know the source of these sediments, but the high riparian pollen content suggests that the sediments either came from a different alluvial source of recent deposition, or that incision of the deposit occurred within the most recent 100 years or so.

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LITERATURE CITED

ADAM, D. P. 1985. Quaternary pollen records from California. Pp. 125–140 *in* V. M. Bryant, Jr. and R. G. Holloway (eds.), Pollen records of Late-Quaternary North American Sediments. American Association of Stratigraphic Palynologists, Dallas, TX.

ANDERSON, R. S. AND S. J. SMITH. 1994. Paleoclimatic interpretations of meadow sediment and pollen stratigraphies from California. Geology 22:723–726.

BAUM, B. 1967. Introduced and naturalized tamarisks in the United States and Canada. Baileya 15:19–25.

BEAUCHAMP, R. M. 1986. A flora of San Diego County, California. Sweetwater River Press, National City, California.

BENSON, L. AND R. A. DARROW. 1981. Trees and shrubs of the southwestern deserts. University of Arizona Press, Tucson.

BYRD, B. F. In Press. Harvesting the littoral landscape during the Late Holocene: new perspectives from Northern San Diego County. Journal of California and Great Basin Anthropology.

BYRD, B. F. 1996. Coastal archaeology of Las Flores Creek and Horno Canyon, Camp Pendleton, California. Report submitted to the U.S. Army Corps of Engineers, Los Angeles District, California. ASM Affiliates, Inc., Encinitas, CA. (Report on file, South Coast Information Center, San Diego State University).

BYRNE, R., J. MICHAELSEN, AND A. SOUTAR. 1977. Fossil charcoal as a measure of wildfire frequency in Southern California: a preliminary analysis. Pp. 361–367 *in* Proceedings of the Symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems. General Technical Report WO-3, USDA Forest Service, Washington, D.C.

COLE, K. L. AND G. LIU. 1994. Holocene paleoecology of an estuary on Santa Rosa Island, California. Quaternary Research 41:326–335.

DAVIS, O. K. 1992. Rapid climatic change in coastal southern California inferred from pollen analysis of San Joaquin Marsh. Quaternary Research 37:89–100.

FALL, P. L. 1987. Pollen taphonomy in a canyon stream. Quaternary Research 28:393–406.

GLASSOW, M. A. AND L. R. WILCOXON. 1988. Coastal adaptation near Point Conception, California, with particular regard to shellfish exploitation. American Antiquity 53:36–51.

HALL, S. A. 1985. Quaternary pollen analysis and vegetational history of the Southwest. Pp. 95–124 *in* V. M. Bryant, Jr. and R. G. Holloway (eds.), Pollen records of Late-Quaternary North American sediments. AASP, Dallas.

HEUSSER, L. E. 1978. Pollen in Santa Barbara Basin, California: a 12,000 year record. Geological Society of America Bulletin 89:673–678.

HUDSON, J. 1996. Vertebrate remains from SDI-811, SDI-4538, and SDI-10,726 at Camp Pendleton. Pp. 241–274 *in* Byrd, B. F. (ed.), Coastal archaeology of Las Flores Creek and Horno Canyon, Camp Pendleton, California. Report submitted to U.S. Army Corps of Engineers, Los Angeles District, California. ASM Affiliates, Inc., Encinitas, CA.

INGHAM, N. D. 1908. Eucalyptus in California. University of California Experiment Station Bulletin 196.

INMAN, D. L. 1983. Application of coastal dynamics to the reconstruction of paleocoastlines in the vicinity of La Jolla, California. Pp. 1–49 *in* P. M. Masters and N. C. Flemming (eds.), Quaternary coastlines and marine archaeology. Academic Press, London.

JONES, T. L. 1991. Marine-resource value and the priority of coastal settlement: a California perspective. American Antiquity 56:419–443.

JONES, T. L. 1992. Settlement trends along the California coast. Pp. 1–38 *in* T. L. Jones (ed.), Essays on the prehistory of maritime California. Center for Archaeological Research at Davis Publications No. 10, Davis, CA.

KOEHLER, P. A. AND R. S. ANDERSON. 1994. The paleoecology and stratigraphy of Nichols Meadow, Sierra National Forest, California, U.S.A. Palaeogeography, Palaeoclimatology, Palaeoecology 112:1–17.

LAMARCHE, V. C. JR. 1973. Holocene climatic variations inferred from treeline fluctuations in the White Mountains, California. Quaternary Research 3:632–660.

LAYLANDER, D. AND D. SAUNDERS. 1993. *Donax* exploitation on the Pacific Coast: spatial and temporal limits. Proceedings of the Society of California Archaeology 6:313–325.

MUDIE, P. J. AND R. BYRNE. 1980. Pollen evidence for historic sedimentation rates in California coastal marshes. Estuarine and Coastal Marine Science 10: 305–316.

PACIFIC SOUTHWEST BIOLOGICAL SERVICES, INC. 1986. Vegetation of Camp Pendleton, Las Pulgas Canyon Quadrangle. Map.

REDDY, S. N. 1996a. Experimental ethnoarchaeological study of *Donax gouldii* exploitation. Pp. 231–240 *in* Byrd, B. F. (ed.), Coastal archaeology of Las Flores Creek and Horno Canyon, Camp Pendleton, California. Submitted to U.S. Army Corps of Engineers, Los Angeles District, California. ASM Affiliates, Inc., Encinitas, CA. (Report on file, South Coast Information Center, San Diego State University).

REDDY, S. N. 1996b. Paleoethnobotanical investigations at Las Flores Creek and Horno Canyon, Camp Pendleton. Pp. 275–304 *in* Byrd, B. F. (ed.), Coastal archaeology of Las Flores Creek and Horno Canyon, Camp Pendleton, California. Submitted to U.S. Army Corps of Engineers, Los Angeles District, California. ASM Affiliates, Inc., Encinitas, CA. (Report on file, South Coast Information Center, San Diego State University).

SCUDERI, L. A. 1987. Late Holocene upper treeline variation in the southern Sierra Nevada. Nature 325:242–244.

SHIPEK, F. C. 1989. An example of intensive plant husbandry: the Kumeyaay of southern California. Pp. 159–170 *in* D. R. Harris and G. C. Hillman (eds.), Foraging and farming: the evolution of plant exploitation. Unwin Hyman, London.

STANFORD, L. G. 1970. San Diego's eucalyptus bubble. Journal of San Diego History 16:11–19.

THOMPSON, R. S., C. WHITLOCK, P. J. BARTLEIN, S. P. HARRISON, AND W. G. SPAULDING. 1993. Climatic changes in the western United States since 18,000 yr B.P. Pp. 468–513 *in* H. E. Wright, Jr., J. E. Kutzbach, T. Webb III, W. F. Ruddiman, F. A. Street-Perrott, and P. J. Bartlein (eds.), Global climates since the last glacial maximum. University of Minnesota Press, Minneapolis.

VOGL, R. J., W. P. ARMSTRONG, K. L. WHITE, AND K. L. COLE. 1988. The closed-cone pines and cypress. Pp. 295–358 *in* M. G. Barbour and J. Major (eds.), Terrestrial vegetation of California. California Native Plant Society, Special Publication 9.

WARREN, C. N. 1964. Cultural Change and Continuity on the San Diego Coast. Ph.D. Dissertation. University of California, Los Angeles.

WATERS, M. R. 1996. Geoarchaeological investigations at Horno Canyon and Las Flores Creek on Camp Pendleton, California. Pp. 47–56 *in* Byrd, B. F. (ed.), Coastal archaeology of Las Flores Creek and Horno Canyon, Camp Pendleton, California. Submitted to U.S. Army Corps of Engineers, Los Angeles District, California. ASM Affiliates, Inc., Encinitas, CA. (Report on file, South Coast Information Center, San Diego State University).

WATERS, M. R., B. F. BYRD, AND S. N. REDDY. 1999. Late Quaternary geology and geoarchaeology of two streams along the southern California coast. Geoarchaeology 14:289–306.

WEST, G. J. AND J. M. ERLANDSON. 1994. A late Pleistocene pollen record from San Miguel Island, California: preliminary results. AMQUA Abstracts 13:256.

ZEDLER, P., J. GIESSOW, S. DESIMONE, D. LAWSON, J. ELSE, AND S. BLISS. 1996. A guide to the plant communities of Camp Pendleton Marine Corps Base, California. Unpublished Manuscript.

Appendix Table 1. Las Flores Creek Alluvial Section Pollen Percentages.

	Sample depth (cm)														
	0	25	50	75	100	150	175	200	225	250	275	300	330	400	450
Tracers	41	456	8	5	100	245	45	276	523	253	101	523	1	7	59
Pollen Sum	308	300	307	310	308	304	202	202	202	95	17	85	0	1	8
Pollen Conc. grains/cc	10141.5	888.2	51806.3	83700.0	4158.0	1675.1	6060.0	988.0	521.4	506.9	227.2	219.4	0.0	192.9	183.1
Deteriorated	5.2	7.3	5.9	9.7	10.7	11.8	8.9	6.4	1.0	6.3	0.0	2.4	0.0	0.0	0.0
Unknowns	1.9	4.0	1.6	1.3	0.3	1.0	0.5	0.0	1.0	1.1	0.0	0.0	0.0	0.0	0.0
Cupressus-type	0.0	0.0	0.0	0.0	0.6	7.2	1.5	7.4	23.3	27.4	X	38.8	0.0	0.0	X
Pinus coulteri/ponderosa	1.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Pinus undifferentiated	0.6	0.3	0.0	0.0	0.0	0.0	0.5	0.5	1.0	0.0	X	1.2	0.0	0.0	0.0
Eucalyptus	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cf. *Olea*	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceanothus	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
cf. Solanaceae	0.0	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asteraceae *Baccharis*-type	40.6	18.7	45.3	42.6	52.9	47.7	59.9	44.6	50.5	36.8	X	38.8	X	X	X
Asteraceae *Coreopsis*-type	0.0	0.0	2.3	0.0	0.0	0.3	0.0	0.5	1.0	3.2	0.0	0.0	0.0	0.0	0.0
Asteraceae *Chaenactis*-type	0.0	0.3	0.0	0.0	0.0	1.0	0.5	0.0	1.0	6.3	0.0	0.0	0.0	0.0	0.0
Asteraceae type-4	0.0	1.3	0.0	1.3	0.3	0.7	0.0	5.4	0.5	2.1	X	0.0	0.0	0.0	0.0
Asteraceae *Solidago*-type	13.6	1.7	17.3	31.6	17.2	5.3	20.3	24.3	12.4	0.0	0.0	7.1	0.0	0.0	0.0
Asteraceae type-6	1.3	0.0	2.3	1.0	1.6	0.0	1.0	2.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Ambrosia	1.9	0.7	0.7	1.0	3.9	11.8	1.0	1.5	1.5	8.4	X	7.1	0.0	0.0	0.0
Cheno-Am	6.8	10.7	8.1	4.8	7.1	0.0	2.5	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Cercocarpus/Rosaceae	0.3	0.7	0.0	0.6	0.0	1.6	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artemisia	0.6	0.0	1.0	1.6	1.0	3.3	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poaceae	0.3	0.0	1.6	0.6	1.0	4.9	1.0	1.0	0.5	1.1	0.0	0.0	0.0	0.0	0.0
Brassica-type	14.6	27.7	12.4	1.0	0.6	0.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	X
Cirsium	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apiaceae *Foeniculum*-type	10.4	17.3	0.3	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	X
Liliaceae	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liguliflorae	0.0	0.7	0.7	0.6	1.0	1.3	0.0	3.5	3.5	6.3	0.0	2.4	0.0	0.0	0.0
Eriogonum	0.0	0.7	0.3	0.6	0.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caryophyllaceae *Silene*-type	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polemoniaceae	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lamiaceae	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Galium	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaeralcea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0
Tamarix	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cf. *Platanus*	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Populus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX TABLE 1. CONTINUED

	Sample depth (cm)														
	0	25	50	75	100	150	175	200	225	250	275	300	330	400	450
Juglans	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alnus	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix	0.6	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyperaceae	0.0	1.0	0.0	0.3	0.3	0.6	0.3	0.3	0.0	5.3	0.0	0.0	0.0	0.0	0.0
Typha	0.3	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0
Cheilanthes-type	0.0	0.0	0.7	0.3	0.3	0.7	1.0	2.0	10.4	2.1	0.0	1.2	0.0	0.0	0.0
Ophioglossum-type	0.0	0.0	0.0	0.3	0.3	0.3	0.5	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Trilete Spore type-3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trilete Spore type-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0